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THE TRUE ROGER BACON, II

WE turn from Bacon's criticism to ask what constructive contributions he made in the direction of modern thought, and, on the other hand, what ideas, now obsolete, still persisted in his philosophy. We cannot regard his mere interest in natural science as especially noteworthy, since many men of the twelfth and thirteenth centuries wrote on nature and even showed signs of an independent scientific spirit. The question therefore becomes whether his method of studying nature was superior to theirs, whether he was unique in such things as his advocacy of mathematics and of experimental science. But let us first consider a side of his thought that has seldom been emphasized, namely, his historical attitude.

In one sense history was a weak point with Bacon as with most of his contemporaries. He not only accepted the faulty accounts of the past current in his day, but was apt to pounce upon the most sensational and incredible details and use these to support his case. He had no notion of historical criticism. Unfortunately he thought that he knew a good deal about the history of philosophy, and his attitude to science is colored by his false ideas of the history of intellectual development. He of course knew nothing of evolution or of prehistoric man. For him intellectual history commenced with a complete divine revelation of philosophy to the patriarchs. Science then declined owing to the sinfulness of mankind, the invention of magic by Zoroaster, and further corruption of wisdom at the hands of Nimrod, Atlas, Prometheus, Hermes Trismegistus, Aesculapius, and Apollo. Complete knowledge and understanding were granted again by God to Solomon, after whom succeeded another period of sinful decline, until with Thales began the gradual upbuilding of Greek philosophy culminating in Aristotle. Then night set in again, until Avicenna revived philosophy among the Arabs. To him and Aristotle, however, as infidels, less complete knowledge was vouchsafed than to the representatives of God's chosen people.[1] Of the composition and development of Roman law Bacon had so little notion that he thought it borrowed chiefly from Aristotle and Theophrastus, except that the Twelve Tables were derived from the laws of Solon.[2] Though he saw the value of linguistics and textual criticism, and sought with true humanistic ardor for a lost work like the

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[1] *Opus Majus*, Bridges, I. 20, 45–56, and 65; *Opus Tertium*, Brewer, pp. 24–25, 32.

[2] *Opus Tertium*, Brewer, p. 50.

Morals of Seneca, he accepted as genuine works of antiquity spurious treatises like the *De Vetula* ascribed to Ovid.[3] He believed that Paul had corresponded with Seneca and that Alexander's conquests were due to Aristotle's experimental science. We shall soon see how he used the astrological interpretation of history, which was the medieval counterpart of our geographical and economic interpretation. Yet Bacon deserves praise for so often opening his discussion of a problem by an inquiry into its historical background; he at least tried to adopt the historical point of view. And on the whole his historical method makes about as close an approach to modern research as do his mathematics and experimental science to their modern parallels.

Yet the introduction of mathematical method into natural science has often been attributed to Roger Bacon, in which respect he has been favorably contrasted with Francis Bacon. Therefore it will be well to note exactly what Roger says on this point, and whether his observations were notably in advance of the thought of his times. The discussion in the *Opus Maius* opens with strong assertions of the necessity for a knowledge of mathematics in the study of natural science and of theology as well; and we are told that neglect of mathematics for the past thirty or forty years has been the ruin of Latin learning. This position is supported by citation of various authorities and by some vague general arguments in typical scholastic style. Grammar and logic must employ music, a branch of mathematics, in prosody and persuasive periods. The categories of time, place, and quantity require mathematical knowledge for their comprehension. Mathematics must underlie other subjects because it is by nature the most elementary and the easiest to learn and the first discovered. Moreover, all our sense knowledge is received in space, in time, and quantitatively. Also the certitude of mathematics makes it desirable that other studies avail themselves of its aid.

But now we come to the application of these glittering generalities and we see what Bacon's "mathematical method" really amounts to. Briefly, it consists in expounding his physical and astronomical theories by means of simple geometrical diagrams. The atomical doctrine of Democritus cannot be true, since it involves the error that the hypothenuse is of the same length as the side of a square. Geometry satisfies Roger that there can be but one universe; otherwise we should have a vacuum left. Plato's assertion that the heavens and four elements are made up each of one group of regular solids is also subjected to geometrical scrutiny. Mathematics is further of service in Biblical geography, in sacred chronology, and in allegorical interpretation of the dimensions of the ark, temple, and tabernacle, and of various numbers which occur in Scripture. But mathematics, according to Bacon, plays its greatest rôle in astronomy or astrology and in physics, and in his favorite theory of multiplication of species or virtues, or, as modern writers have flatteringly termed it, the propagation of force.[4]

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[3] Pierre d'Ailly in 1410 in *De Legibus et Sectis*, cap. 4, pointed out that Bacon was relying upon a spurious work.

Astronomy and astrology had together long made up the world's supreme science; there was no originality in urging their importance. In physics Bacon borrowed his discussion of weights and falling bodies from Jordanus, an earlier writer in the thirteenth century, and his optic from Alhazen and Grosseteste and from treatises which passed then under the names of Ptolemy and Euclid but were perhaps of more recent origin.[5] Bacon's graphic expression of the multiplication of species by lines and figures we find earlier in Grosseteste's *De Lineis, Angulis, et Figuris.*[6] It does not seem, therefore, that Bacon made any new suggestions of great importance concerning the application of mathematical method in the sciences, and historians of mathematics have recognized that "he contributed nothing to the pure science",[7] of whose very meaning his notion was inadequate.

In considering Bacon's "mathematics" we must never forget that for him the term included astrology, which in truth seemed to him by far the most important and practical part of mathematics. By its aid he believed that the future could be foretold and also that marvellous operations and great alterations could be effected throughout the whole world, especially by choosing favorable hours and by employing astronomical amulets and characters. If a doctor does not know astronomy, his medical treatment will be dependent on "chance and fortune".[8] Recent bloody wars might have been avoided had men harkened to warnings written in the sky.[9] Bacon was very desirous that the Church should avail itself of the guidance of astrology; and he feared the harm that Antichrist, or the

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[4] Little, *Essays*, p. 16, quoting Adamson, *Roger Bacon: the Philosophy of Science in the Middle Ages* (1876), which is now out of print.

[5] Ptolemy's *Optics* is known only in Latin form, supposedly translated from the Arabic, edited by Govi (Turin, 1885); see Bridges, I. lxx. The *Optica* ascribed to Euclid is contained in Heiberg's edition (Leipzig, 1895).

[6] Baur, in Little, *Essays*, pp. 46–47.

[7] D. E. Smith, in Little, *Essays*, p. 171, citing Heilbronner and other historians of mathematics. Professor Smith has very kindly permitted me to see in manuscript form his forthcoming edition of the *Communia Mathematicae* of Roger Bacon.

[8] Gasquet, "An Unpublished Fragment of a Work by Roger Bacon", *English Historical Review*, XII. 516.

[9] Bridges, I. 386.

Tatars with their astrologers, would do Christendom, if the Church neglected this art.[10]

Bacon thought the stars ungenerated, incorruptible, voluntary in their movements, which were due to angelic intelligences.[11] He asserted that "it is manifest to everyone that the celestial bodies are the causes of generation and corruption in all inferior things".[12] This was, indeed, for all men of his time with any scientific pretensions, a fundamental law of nature. In explaining the operation of this celestial influence Bacon accepted the usual technique of the astrological art.[13] He further believed that the "complexions" or physical constitutions of human beings were determined by the constellations at the time of conception and birth, and that with each passing hour the rule of the body passed from one planet to another. He even held that the stars by their influence upon the human body incline men to bad acts and evil arts or to good conduct and useful sciences. Such natural inclinations might, however, be resisted by effort of will, modified by divine grace, or strengthened by diabolic tempting. Bacon, indeed, was always careful to exempt the human will from the rule of the stars; he explains that what the canon law condemns in its penalties against the *mathematici* is the false and superstitious variety of *mathematica* which accepts the doctrine of fatal necessity. But Bacon contends that true astrologers like Haly, Ptolemy, Avicenna, and Messahala have never held this doctrine, though common report ignorantly attributes it to them. While the individual by an effort of will may resist the force of the stars, in masses of men the power of the constellations usually prevails; and the differences in peoples inhabiting different parts of the earth are due to their being under different aspects of the sky. The personality of the king, too, has such great influence upon his kingdom that it is worth while to examine his horoscope carefully. Even Jesus Christ, in so far as his nature was human and his birth natural, was, like the rest of humanity, under the influence of the constellations; and the virgin birth was, as Albumasar states, foreshown by the stars.

Bacon was especially attracted by the doctrine of Albumasar concerning conjunctions of the planets, and derived comforting evidence of the superiority of the Christian faith to other religions from the astrological explanation of the origin of religious sects according to the successive conjunctions of the other planets with Jupiter.[14] He was pleased by the association of Christianity with Mercury, which he calls the lord of wisdom and eloquence, of oracles and prophecies; it is dominant only in the sign Virgo, which at once suggests the Virgin Mary; and its orbit, difficult to trace because of epicycle and eccentric, typifies well the Christian creed with its mysteries that defy reason. Similarly the malign force of the moon, productive of necromancy and magic, fits Antichrist exactly; and Venus corresponds to the sensuality of Mohammedanism. Further astrological evidences of Christianity are the coincidence six years before the birth of Christ of an important conjunction of Saturn and Jupiter with a tenth revolution of Saturn, which last occurs only at intervals of 320 years and always marks some great historical change like the advent of Alexander or Manes or Mohammed. Astrology further assures us that Islam can endure only 693 years, a prediction in close agreement with the number of the beast in the Apocalypse, 663 (*sic*)[14a]; the small discrepancy of thirty years is readily accounted for by the dictum of the venerable Bede that "Scripture in many places subtracts something from the complete number, for that's the way with Scripture."

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[10] *Ibid.*, pp. 399–403.

[11] Steele, *Opera hactenus inedita Rogeri Baconi*, fasc. I., p. 12; fasc. III., pp. 228–239; Bridges, II. 450.

[12] *Opus Tertium*, Brewer, p. 107, and several other passages.

[13] Astrology is discussed by Bacon in Bridges, I. 138–143, 238–269, and 376–404; Gasquet, pp. 512–516; *Opus Tertium*, Brewer, pp. 105–106, 271–272; *Opus Minus*, Brewer, pp. 320–321; *Compendium Studii*, Brewer, pp. 421–422; Little, *Part of the Opus Tertium*, pp. 1–19; and in many scattered passages.

We have perhaps sufficiently illustrated the loose logic that could satisfy a man whom some have thought the first to suggest the mathematical method of modern science. But it must be added that Bacon believed that art as well as nature was governed by the constellations; that "every new-made thing received the virtue of the sky" just as the babe was supposed to receive it at birth; that images could acquire great virtues by being carved upon gems under certain aspects of the heavens. As he held that saints and patriarchs of old had been great astrologers, so he declares that Moses and Solomon were adepts in this art of images, and that by it "all injuries can be repelled and useful undertakings promoted".

In these mistaken notions Roger was quite as representative of his age as in his interest in natural science. We find Christian astrologers in the declining Roman empire;[15] dream-books and moon-books, and tracts on divination from thunder and the kalends of the month, and the "Sphere of Apuleius" with its Egyptian days are found through the Carolingian and Anglo-Saxon periods.[16] In the twelfth century Bernard Sylvestris[17] wrote poems and treatises of an uncompromising astrological character, and Daniel Morlay brought back to England from Spain the astrology of his Arabian teachers. The work of translating the Arabian astrologers went on apace, and in the writings of such Latins of the thirteenth century as Michael Scot, Alexander Neckam, Bartholomew of England, Robert Grosseteste, and the author of the *Summa* ascribed to him, Vincent of Beauvais, Ramon Lul, Guido Bonati, Albertus Magnus, Thomas Aquinas, Peter of Abano, and Arnald of Villanova, we find Bacon's opinions again in part or *in toto*.[18] With his views on astrological images and his attribution of religious sects to conjunctions of the planets theologians like Aquinas and William of Auvergne would refuse to agree, but Arabian astrology supported such doctrines, and the views of an approved Christian thinker like Albertus Magnus concerning astrology are almost identical with those of Bacon.

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[14] Both this doctrine and Albumasar's reference to the birth of Jesus are given in Steele, *Opera hactenus inedita*, fasc. I., pp. 42–50, and 8–9, as well as in the passages listed in note 13.

[14a] Bridges, I. 266: "Et huic sententiae concordat apocalypsis xiii capitulo. Nam dicit quod numerus bestiae est 663, qui numerus est minor praedicto per xxx annos. Sed scriptura in multis locis subticet aliquid de numero completo, nam hic est mos scripturae ut dicit Beda."

[15] Hephaestion of Thebes apparently was a Christian astrologer at the close of the fourth century of our era, Engelbrecht, *Hephästion von Theben und sein Astrologisches Compendium* (Vienna, 1887). So perhaps was Julius Firmicus Maternus, whose Latin *Mathesis* was known in the West in the eleventh and

There is therefore almost no ground for attributing the reported condemnation of Roger in 1278 to his astrology, nor for assigning the authorship of the *Speculum Astronomiae* to him rather than to Albertus.[19] Such attribution has arisen from misapprehensions as to the views of Bacon's contemporaries and from misstatements such as the passage in Charles's life of Bacon,[20] where he declares that Cardinal Pierre d'Ailly in his treatise on laws and sects condemns the doctrine of an English doctor concerning religions and the conjunctions of planets, and approves the contrary doctrine of William of Auvergne, but "does not dare" to name Bacon, to whom he alludes with the bated breath of terror and repugnance. All this is sheer fancy on Charles's part. Had he consulted a complete fifteenth-century edition of d'Ailly's writings instead of merely such of his

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twelfth centuries, Thorndike, "A Roman Astrologer as a Historical Source", *Classical Philology*, October, 1913. For other Christian astrologers, especially Byzantine ones, see *Catalogus Codicum Graecorum Astrologorum* (Brussels, 1898–).

[16] Frankish astrology is discussed in the *Histoire Littéraire de la France*; a number of tenth- and eleventh-century MSS. in the British Museum show the prevalence of astrology in England before the Norman conquest.

[17] His *Mathematicus* and *De Mundi Universitate* have been printed in Migne, *Patrologie*, CLXXI., and by Barach and Wrobel (Innsbruck, 1876), respectively, but his Experimentarius, a geomancy, is still in manuscript only.

[18] My assertion is based upon first-hand study of the writers named. The *Hist. Litt. de la France*, XXIX. 309, gives the impression that one of Lully's treatises is an attack upon astrology, but he accepts most of the essentials of the art.

[19] As has been done by Father Mandonnet, "Roger Bacon et le *Speculum Astronomiae*", *Revue Néo-Scolastique*, 1910.

[20] P. 49.

treatises as were included in an eighteenth-century edition of the works of Gerson, he would have known that elsewhere the cardinal cites Bacon on astrology by name with respect and admiration,[21] and that the learned reformer even goes so far as to agree boldly and explicitly with Bacon's doctrine that Christ as a son of man was under the stars.[22] That Bacon's astrology had not been condemned in 1278 is also indicated soon after his death by Pierre Dubois's approving mention of his discussion of the utility of "mathematics".[23]

Jebb's edition of the *Opus Maius* in 1733 ended with the sixth part on "Experimental Science", which thus seemed the climax of the work and helped to give the impression that Bacon put natural science first, and experimental method first in the study of nature. Bridges's edition added the seventh part, on "Moral Philosophy", "a science better than all the preceding", and the text as now extant, after listing various arguments for the superiority of Christianity to other religions, concludes abruptly with an eight-page devout justification and glorification of the mystery of the Eucharist.

It is, however, significant that "experimental science" is the last of the natural sciences discussed by Bacon. As we read his praises of it, we see that he is not so much thinking of an inductive method through regulated and purposive experience and observation to the discovery of truth—although his discussion of the rainbow is an example of this—as he is thinking of applied science which puts to the test of practical utility the results of the "speculative" natural sciences, and is thus not like modern experimentation the source but "the goal of all speculation". "Other sciences know how to discover their first principles through experience, but reach their conclusions by arguments made from the principles so discovered. But if they require a specific and final test of their conclusions, then they ought to avail themselves of the aid of this noble science."[24] "Natural philosophy narrates and argues but does not experiment. The student of perspective and the astronomer put many things to the test of experience, but not all nor sufficiently. Hence complete experience is reserved for this science."[25] It uses the other sciences to achieve definite practical results; as a navigator orders a carpenter to build him a ship or a knight tells a smith to make him a suit of armor, so the *experimentator* uses his knowledge of geometry to construct a burning-glass or outdoes alchemy at its own specialty of gold-making.[26] In working out these practical inventions, however, the "experimenter" often happens on new facts and truths of which the speculative sciences have not dreamed, and in this way experimental science "by its own power investigates the secrets of nature".

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[21] In his *Apologetica Defensio Astronomice Veritatis* he cites "Bacon magnus doctor anglicus in epistola ad Clementem papam"; in his *Alia Secunda Apologetica Defensio eiusdem,* arguing that the superstition of certain astrologers does not invalidate the art, he says, "Et hoc pulcre et diffuse probat Bacon in epistola ad papam clementem"; and in his *Elucidarius* he definitely says that it was Bacon whose theory of conjunctions and sects he discussed in the *De Legibus et Sectis.*

[22] In the *Apologetica Defensio* and again in the *Vigintiloquium.*

[23] *De Recuperatione Terre Sancte* (ed. Langlois), p. 65.

[24] Bridges, II. 172–173; *Opus Tertium,* Brewer, p. 43.

[25] Little, *Part of Opus Tertium,* p. 44.

Moreover, we may fairly credit Bacon with all the signs of experimental method that we can find in his optic, alchemy, astronomy, and astrology, as well as in his separate section on "experimental science". Even so his ideas seem little further developed than were his notions of the mathematical method. He emphasizes experience as a criterion of truth and believes further in purposive experimentation, but makes no definite suggestions of value as to how one is to proceed, and has no conception of the scientific methods of a modern laboratory. Rather is his mind credulously fixed upon the marvels which he expects experimental science to achieve by methods that seem to us fantastic and occult.[27]

Nor in this is Bacon striking off a new though crude conception of his own; he is presenting a position found in writers before him, and is revealing the merits and defects of an important movement of his time. When, for example, we read in the works of Robert Grosseteste, bishop of Lincoln, not only many such phrases as "experiences and reasons" or "authorities and experimenters", but also a discussion of opinions concerning comets based on "experiments in natural objects", in which Grosseteste mentions experimenters who "fall into various false opinions about the nature of comets according to their diversified experiments with rays and generated fires" and lenses—when we read this, we realize that Bacon's discussion of the rainbow in this section on "experimental science" is nothing extraordinary. Grosseteste also mentions "experts" who have discovered the magnifying properties of lenses.[28] When we read the *De Universo* of William of Auvergne, bishop of Paris, with its numerous citations from books of experiments and books of magic and necromancy and witchcraft,[29] or the twelve experiments with a snake's skin translated into Latin by the celebrated John of

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[26] *Opus Tertium,* Brewer, p. 44–45.

[27] For a fuller discussion of Bacon's experimental method and a comparison with his contemporaries, see my "Roger Bacon and Experimental Method in the Middle Ages", in the *Philosophical Review,* May, 1914, pp. 271–298.

[28] Baur, *Die Philosophischen Werke des Robert Grosseteste* (Münster, 1912), pp. 13, 25, 33, 34, 36, 40, 41, 68, etc.

[29] *Gulielmi Alverni Episcopi Parisiensis . . . Opera Omnia* (Venice, 1591), pp. 599, 606, 608, 860, 968, 988, 998–999, 1003, 1010.

Spain,[30] or the similar experiments with pulverized snake's skin of Nicholas of Poland,[31] or the natural experiments that Solomon was supposed to have performed out of love for a certain queen,[32] or the *Experimenta Alberti* with their assertion that the science of magic is not necessarily evil[33]—when we have read books of this sort, we understand better the marvellous and occult character of Bacon's "experimental science" with its tales of the experiment with a snake performed by a sage at Paris and of the beneficial effect of eating the flesh of good flying dragons.

As Bacon's discussion of mathematics led us to a consideration of his belief in astrology, so his discussion of experimental science leads us to examine his attitude toward magic, since he admits that many persons confuse the two.[34] He, however, declares that experimental science detects and avoids the follies and deceits of magic. His pages are full of condemnatory or contemptuous allusions to magic. He will not admit that magicians employ natural forces nor that their methods of operating are valid. Their apparent feats he either explains away, as we do the stage and parlor magic of to-day, by sleight-of-hand, ventriloquism, mechanical devices, confederates, and other deceptions; or he accounts for them as the work of evil spirits. Thus magicians are either impostors or instruments of the devil. Bacon contends that demons are not coerced by the properties of natural objects, and he does not sanction such an expression as "natural magic". Yet he waxes enthusiastic over "the secret works of art and nature", and he complains that these are often confused with magic, and that contemporary theologians, canonists, and holy men "have condemned many useful and splendid sciences along with magic". Besides astrology and its corollary science of images, he would justify to a certain extent as "philosophical" the employment of occult virtues in natural objects, and of characters, incantations, the human voice, and the rational soul, in order to produce marvellous changes in things and persons. He asserts that experimenters and philosophers can by these methods work far greater wonders than the magicians ever perform.

Thus Bacon fails in his attempt to draw the line between science and magic. His science still includes many occult and magical elements of whose true character he is not aware, while he admits that the magicians often try to or pretend to use scientific books and methods, and that it is no easy matter to tell which books and characters and images are which. The experimental scientist not only exposes the frauds of magic but discovers secrets of nature hidden beneath the husk of magical ceremony and pretense. Also some men employ the marvels of philosophy for wicked ends and so pervert it into a sort of magic. Finally in one passage he forgets himself and speaks of "those magnificent sciences" which properly employ "images, characters, charms, prayers, and deprecations" as "magical sciences".[35]

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[30] At the British Museum, Arundel MSS., 251, fol. 35v; Sloane MSS., 1754, fol. 30. At Erfurt, Amplon. Folio 276, fol. 69: "Tractatus Alani de xii experimentis corio factis ex Arabico in Latinum a Iohanne Paulino translatus."

[31] Sloane MSS., 1754, fol. 28r; Amplon. Folio 276, fol. 66.

[32] Sloane MSS., 121, fol. 90v.

[33] Sloane MSS., 342, fol. 130r; *ibid.*, 351, fol. 25r; Arundel MSS., 251, fol. 25r; Royal 12 B xxv, fol. 248r; and in many other manuscripts.

[34] I have already treated of Bacon's attitude toward magic in pages 134–138 of "Some Medieval Conceptions of Magic" in the *Monist*, XXV. 107–139 (January, 1915), where citations will be found for the passages used.

Bacon's doctrine of the multiplication of species is a good illustration of the combination of magic and science which we encounter in his works. This theory has been praised by his admirers as the propagation of force subject to mathematical law; and he has been commended for describing the species which every agent causes in all directions not, like the idols of Lucretius, as material films which peel off from the agent and impress themselves on surrounding matter, but as successive effects produced in that matter. Bacon usually illustrates his theory by the radiation of light from the sun, and by a discussion of the geometrical laws of reflection and refraction; thus his theory seems at first sight a physical one. He believed, however, that the occult influences of the planets upon nature and man were exercised in the same way, and also such mysterious powers as those of the evil eye and of fascination. Indeed, he asserts that this multiplication of virtues is universal, and that spiritual beings as well as corporeal objects affect in this manner everything about them and may themselves be so affected by other objects and beings.[36] Viewed from this angle, his theory seems a magical one of occult influence, though given a scientific guise by its assumption that such forces proceed along mathematical lines after the analogy of rays of light. This suggests that it is not fair merely to call Bacon's science superstitious; we must also note that he tries to make his magic scientific.

It seems somewhat strange that Bacon should fight so shy of the word "magic", when his predecessor, William of Auvergne, and his contemporary, Albertus Magnus, both allude to magic as sometimes bordering upon science, in which case they do not regard it unfavorably. Yet William, as we have noted, was less favorable to astrology than Roger. The good Bishop of Paris, who certainly shows himself well versed both in magical literature, black and white, and in popular superstitious practices, condemns much of such lore and custom as tantamount to idolatry or worship of demons; he refuses to believe in some of the marvels which magic claims to work, and denies the powers ascribed to incantations, characters, and images, though he is less sure as to words or the occult influence of the soul. But he asserts that one of the eleven subdivisions of science is "natural magic", by which marvels are performed naturally which the ignorant crowd takes for the work of demons, but which usually are inoffensive.[37] He also frequently refers to "sense of nature", a sort of occult power such as the ability to sense a threatening but hidden danger; this is "one of the roots of natural magic".[38] William indeed displays a more detailed knowledge of magic than Bacon does. In his theological works Albert sometimes condemns magic, yet even there attributes its marvels in large measure to natural forces and to the influences of the stars. In his scientific writings he occasionally alludes to "magic" without censure, speaking of "alchemy and magic", of "astronomy and magic and the necromantic sciences", and of "magical sciences". He classifies as magic several of Bacon's "secret works of art and nature", though, like Bacon, he appears to regard them with approval.[39] For these reasons I can as little believe that Bacon was condemned in 1278 for magic as that he was condemned for astrology, especially since he apparently did not dabble in the invocation of demons.

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[35] Little, *Part of the Opus Tertium*, pp. 17–18: "Et ideo si ecclesia de studio ordinaret, possent homines boni et sancti laborare in hujusmodi scientiis magicis auctoritate summi pontificis speciali."

[36] Bridges, I. 111: "Omne enim efficiens agit per suam virtutem quam facit in materiam subjectam, ut lux solis facit suam virtutem in aere, quae est lumen diffusum per totum mundum a luce solari. Et haec virtus vocatur similitudo, et imago, et species, et multis nominibus, et hanc facit tam substantia quam accidens, et tam spiritualis quam corporalis. Et substantia plus quam accidens, et spiritualis plus quam corporalis. Et haec species facit omnem operationem hujus mundi; nam operatur in sensum, in intellectum, et in totam mundi materiam pro rerum generatione."

On the other hand, it is apparent that in his inclusion of magical factors in natural science he is an exponent of what we may call the school of natural magic and experiment. If we turn from writers whose works have been printed, like Albert and William, to old collections of manuscripts like that of Amplonius at Erfurt and of Sir Hans Sloane in the British Museum, we become the more convinced that occult and natural science, magic and experiment were closely associated in Bacon's time. "Experimental books" are full of magic and magicians repeatedly perform experiments. Down through the seventeenth century the word "experiment" continues to be associated with feats of magic, and earlier it is applied freely to books of divination and astrology. In medieval collections of recipes and experiments we find bizarre magic mixed in with directions for blowing soap-bubbles, true chemical processes, and new discoveries such as alcohol. Alchemy was becoming more practical and scientific, less given to mystic language and fantastic rigmarole than among the Greeks and Arabs. Albertus Magnus and Thomas Aquinas are said to have reconciled Aristotle with Christian theology; Roger Bacon desired that the Church should similarly adopt the alchemy and "experimental science", the "natural magic" and inventions of the age.

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[37] *De Legibus,* caps. 14 and 24; *De Universo,* I. i. 43, 46, and II. iii. 21, 22, 23; in *Opera Omnia* (Venice, 1591), pp. 44, 67, 612, 627, 997, 999, 1003.

[38] *De Legibus,* cap. 27 (*Opera,* p. 88). See Bridges, II. 421, where Bacon possibly copies William in speaking of the mysterious sense by which the sheep apprehends and shuns the species of the wolf.

[39] For Albert's attitude to magic in more detail see "Some Medieval Conceptions of Magic", the *Monist,* XXV. 115–120.

Most medieval books impress one as literary mosaics where the method of arrangement may be new but most of the fragments are familiar. One soon recognizes, however, that striking similarity in two passages is no sure sign that one is copied from the other. The authors may have used the same Arabian sources or simply be repeating some commonplace thought of the times. Men began with the same assumptions and general notions, read the same limited library, reasoned by common methods, and naturally often reached the same conclusions, especially since the field of knowledge was not yet so extensive but that one man might try to cover it all, and since all used the same medium of thought, the Latin language. New discoveries were being made occasionally but slowly, perhaps also sporadically and empirically. A collection of industrial and chemical recipes in the thirteenth century may in the main be derived from a set of the seventh century or Hellenistic age, but a few new ones have somehow got added to the list in the interim. Thomas of Cantimpré's encyclopaedia professes to be no more than a compilation, but it seems to contain the first allusion we have to modern plumbing.[40]

Bacon's chief book was a mosaic like the rest, but bears a strong impress of his personality. Sometimes there is too much personality, but if we allow for this, we find it a valuable, though not a complete nor perfect, picture of medieval learning. Its ideas were not brand-new; it was not centuries in advance of its age; but while its contents may be found scattered in many other places, they will scarcely be found altogether anywhere else, for it combines the most diverse features. In the first place it is a "pious" production, if I may employ that adjective in a somewhat objectionable colloquial sense to indicate roughly a combination of religious, theological, and moral points of view. In other words, Bacon continues the Christian attitude of patristic literature to a certain extent; and his book is written by a clergyman for clergymen, and in order to promote the welfare of the Church and Christianity. There is no denying that, hail him as one may as a herald of modern science. Secondly, he is frequently scholastic and metaphysical; yet thirdly, is critical in numerous respects; and fourthly, insists on practical utility as a standard by which science and philosophy must be judged. Finally, he is an exponent of the aims and methods of what we have called "the natural magic and experimental school", and as such he sometimes comes near to being scientific. So there is no other book like the *Opus Maius* in the Middle Ages, nor has there been one like it since; yet it is true to its age[41] and is still readable to-day. It will therefore always remain one of the most remarkable books of the remarkable thirteenth century.

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[40] British Museum, Egerton MSS., 1984, fol. 141v: "Stagnum . . . in aqua diu jacens de facili conputrescit. Unde fistule aqueductus que subterranea fieri solebant ex plumbo et consolidari ex stagno, *modernis temporibus* ex calido fusili plumbo consolidare ars hominum excogitavit, eo quod soliditate stagno durare non poterant in longinquum, plumbum enim sub terra semper durat."

LYNN THORNDIKE.

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[41] That is to say, in a large sense.